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# FOREIGN TECHNOLOGY DIVISION

THE PROBLEM OF THE MECHANISM OF PROTECTIVE ACTION OF PLASTIC GREASES AND THIN-FILM COATINGS

by

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13. ABSTRACT

Addition

Addn. of 10% AKOR-1 corrosion inhibitor to hydrocarbon grease and more moisture and cation permeable Tsiatim-201 soap lubricants raised their OHM resistance from 137 and 67 to 1270 and 140 Omega and their polarization resistance from 21,663 and 2493 to 43,230 and 17,1760 Omega. Addn. of 10% MOS2 changed the OHM resistance to 100 and 190 Omega and the polarization resistance to 32,000 and 6400 Omega. In Tsiatim-201, 10% AKOR-1+10% MOS2 raised the resp. resistances to 500 and 42,7000 Omega. Parallel corrosion data were obtained. MOS2 and AKOR-1 affected only the bulk protective quality of the dense hydrocarbon grease but affected the surface protective quality of the plastic soap. VNIINP, Moscow, USSR AP1205541

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| | ROLE | WT | ROLE | WT | ROLE | WT |
| Grease | | | | | | |
| Protective Coating | | | | | | |
| Corrosion Inhibitor | | | | | | |
| Molybdenum Disulfide/(U)TSIATIM201 Lubricant | | | | | | |
| (U)AKORI Lubricant | | | | | | |



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| Block | Italic | Transliteration | Block | Italic | Transliteration |
|---|---|---|---|---|---|
| А а | *А а* | A, a | Р р | *Р р* | R, r |
| Б б | *Б б* | B, b | С с | *С с* | S, s |
| В в | *В в* | V, v | Т т | *Т т* | T, t |
| Г г | *Г г* | G, g | У у | *У у* | U, u |
| Д д | *Д д* | D, d | Ф ф | *Ф ф* | F, f |
| Е е | *Е е* | Ye, ye; E, e* | Х х | *Х х* | Kh, kh |
| Ж ж | *Ж ж* | Zh, zh | Ц ц | *Ц ц* | Ts, ts |
| З з | *З з* | Z, z | Ч ч | *Ч ч* | Ch, ch |
| И и | *И и* | I, i | Ш ш | *Ш ш* | Sh, sh |
| Й й | *Й й* | Y, y | Щ щ | *Щ щ* | Shch, shch |
| К к | *К к* | K, k | Ъ ъ | *Ъ ъ* | " |
| Л л | *Л л* | L, l | Ы ы | *Ы ы* | Y, y |
| М м | *М м* | M, m | Ь ь | *Ь ь* | ' |
| Н н | *Н н* | N, n | Э э | *Э э* | E, e |
| О о | *О о* | O, o | Ю ю | *Ю ю* | Yu, yu |
| П п | *П п* | P, p | Я я | *Я я* | Ya, ya |

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

# THE PROBLEM OF THE MECHANISM OF PROTECTIVE ACTION OF PLASTIC GREASES AND THIN-FILM COATINGS

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Studies were carried out on an installation for measuring ohmic and polarization resistance [1, 2] in order to clarify the relationship of the surface and volume components of the protective effect of plastic greases.

Greases – hydrocarbon (gun grease) and soap (TsIATIM-201) – and also the same greases containing a water-soluble corrosion inhibitor – additive AKOR-1 – and molybdenum disulfide as a filler were analyzed. The study showed (Table 1) that the insulating (ohmic) component is not of decisive significance in evaluating protection from electrochemical corrosion by films of greases, since the fraction of ohmic resistance is not great in terms of

*Translator's note. No expansion found for MOPZ.

the total resistance of the protective film, even in uninhibited greases.

Polarization resistance is one order and, in certain cases two orders higher in absolute magnitude than the ohmic resistance.

The insulation component of the protective effect of the lubricants and of film coatings depends on the thickness of the layers, their permeability to vapor, moisture, and gases, and the hygroscopicity of the layer. The indices named are connected with the structure, the rheological and adhesion properties, and the chemical and colloidal stability of the lubricants.

Film tensile strength, the susceptibility to washing away by rain, and the creep temperature are important factors.

A decisive role is played in the protective effect by the polarization component and by the inhibiting of electrochemical corrosion processes connected with it. Polarization can arise for different reasons [3]. First of all, it may appear as he result of difficulty in the progress of electrochemical reactions under the lubricant layer; secondly, it may be caused by anode or cathode concentration polarization, which depends on the structure of the grease, thickness of its layer, storage conditions, and the operation of metal articles. Analysis of polarization curves under a layer of uninhibited hydrocarbon grease (gun grease, petrolatum, petrolatum with rubber) showed preferential inhibition of the anode process [7].

If the ions which form on the surface of the metal are not drawn from the surface mechanically (as the result of friction) or chemically (as the result of reaction with the grease), they accumulate on the surface of the metal and give rise to concentration polarization of the anode with the appropriate shift

Table 1. Ohmic and polarization resistance under a layer of lubricant 100-150 μm.

| (1) Защитный материал | Общее сопротивление, ом (2) | Омическое сопротивление, ом (3) | Поляризационное сопротивление, ом (4) | Относительное поляризационное сопротивление (ОПС), % (5) | Относительное омическое сопротивление (ООС), % (6) |
|---|---|---|---|---|---|
| (7) Чистые пластинки, сталь 45 | 1335 | 51,0 | 1284 | 0 | 0 |
| (8) Масло АС-6 | 1390 | 110,0 | 1280 | 0 | 62 |
| (9) Пушечная смазка | 21800 | 137 | 21663 | 94,1 | 62,7 |
| (10) То же +10% АКОР-1 | 44500 | 1270 | 43230 | 97,2 | 96 |
| (10) То же +10% $MoS_2$ | 32100 | 100 | 32000 | 96 | 50 |
| (11) Смазка ЦИАТИМ-201 | 2560 | 67 | 2493 | 48,4 | 24,0 |
| (10) То же +10% АКОР-1 | 17900 | 140 | 17760 | 92,8 | 63,6 |
| (10) То же +10% $MoS_2$ | 6590 | 190 | 6400 | 80,0 | 74,0 |
| (10) То же +10% АКОР-1 +10% $MoS_2$ | 43200 | 500 | 42700 | 97 | 90,0 |

Remark. The quantities RPR and ROR are calculated with respect to the pure plates.

KEY: (1) Protective material; (2) Total resistance, ohms; (3) Ohmic resistance, ohms; (4) Polarization resistance, ohms; (5) Relative polarization resistance [RPR] (ОПС), %; (6) Relative ohmic resistance [ROR] (ООС), %; (7) Clean plates; steel 45; (8) Oil AS-6; (9) Gun grease; (10) The same; (11) Grease TsIATIM-201.

(improvement) of the potential toward positive values. However, if a soap grease contains components capable of interacting with hydrated metal ions and if it possesses sufficient permeability for these ions, the anode reaction can proceed at a fairly high rate. Removal of ions and intensification of chemical and electrochemical corrosion may be caused by free acids contained in the grease and by other corrosion-aggressive substances formed in the process of operation and oxidation of the grease.

In the case of free flow of the anode process the cathode reaction will be the factor which limits the total rate of corrosion. V. M. Martynov [4] believes that the rate at which the depolarizer – oxygen – diffuses through the layer of plastic greases is a basic factor in their protective action. However, greases (in their oil phase) and the absorption film of water on metal contain oxygen in a quantity which is fully sufficient for the development of electrochemical corrosion. Besides this, the rate of oxygen of diffusion through the layer of the majority of greases is quite great and cannot inhibit the process of corrosion as a whole. It is also impossible to regard the diffusion of oxygen exclusively as a mechanical process, since oxidation processes connected with the formation of radicals, peroxides, and hydroperoxides occur in greases; these substances can in themselves become depolarizers of the cathode process. Migrating ions and corrosion products – scale, rust, etc. – can act as depolarizers under a layer of lubricant.

Results from studying the permeability of greases confirmed the preferential inhibition of the anode process. The permeability of grease films to metal ions was studied with polarization by direct current on two plates protected by a layer of the investigated grease with various thicknesses and lowered into 5% solutions of $CuSO_4$, $FeCl_2$, and $FeCl_3$. The polarization current voltage was varied from 0.5 to 10 V; experiment duration ranged from 15 min to 3 h, with the temperature 20°C. Permeability was evaluated in terms of the change in weight of the plates and by the increase in the ash content of the grease.

From a comparison of the data in Tables 1 and 2 it is clear that, as one would expect, the lower the permeability of the grease to metal cations the higher the ohmic and, especially, polarization resistance of the greases. Hydrocarbon greases (gun grease) possess substantially lower permeability to metal ions and moisture than soap greases; they have higher values of ohmic and polarization resistances.

Table 2. Protective properties of greases.

| (1) Защитный материал | (2) Влагопроницаемость* | (3) Проницаемость для ионов $Cu^{++}$, $г/м^2$ | (4) Испытания на коррозию пластин из стали 45, баллы** | | |
|---|---|---|---|---|---|
| | | | (5) Термовлагокамера Г-4, 50 суток | (6) Камера $SO_2$, 24 ч | (7) Погружение в морскую воду, 4 суток |
| (8) Масло АС-6 . . . . | 42 | — | 10 | 10 | 10 |
| (9) Пушечная смазка . . | 12 | 0,8 | 0,5 | 8 | 10 (смазка сползла) (13) |
| (10) То же +10% АКОР-1 | — | 0 | 0 | 4 | 0,6 |
| (10) То же +10% $MoS_2$ | 29 | 1,7 | 2 | 10 | 10 (смазка сползла) (13) |
| (11) Смазка ЦИАТИМ-201 | 22 | 12,3 | 3,5 | 1,5 | 4 |
| (10) То же +10% АКОР-1 | 10 | 0,6 | 0 | 0,01 | 0 |
| (10) То же +10% $MoS_2$ | 28 | 7,2 | 3,5 | 0,5 | 2,5 |
| (10) То же +10% АКОР-1 +$MoS_2$ . . . . . | 14 | 0,9 | 0 | 0 | 0 |
| (12) Пленочное защитное ингибированное покрытие ЗИП . . . | 0,25 | 0 | 0 | 0 | 0 |

*Increase in the mass of anhydrous copper sulfate, mg, in 5 days under a coating layer 1 mm thick related to 1 $cm^2$ of coating surface.

**0 marks – clean plate; 10 marks – entire surface of the plate covered by corrosion.

KEY: (1) Protective material; (2) Moisture permeability*; (3) Permeability to $Cu^{++}$ ions, $g/m^2$; (4) Corrosion tests, plates of steel 45, marks**; (5) G-4 thermal and humidity chamber, 50 days; (6) $SO_4$ chamber, 24 h; (7) Immersion in sea water, 4 days; (8) Oil AS-6; (9) Gun grease; (10) The same; (11) Grease TsIATIM-201; (12) Protective film, inhibited coating ZIP; (13) (grease crept).

When comparing the permeability of the greases to $Cu^{++}$ ions with permeability to oxygen [4], the lower permeability of the films for hydrated metal ions than for oxygen should be noted. Results of tests of the protective properties of lubricants by widely accepted methods [5, 6] confirmed the data from the electrochemical investigations (see Table 2).

One of the reasons for the high polarization resistance for inhibited greases and thin-film coatings is the formation of adsorption and chemosorption films by surface-active substances.

Tables 1 and 2 show the results of studies on the influence of a filler ($MoS_2$) on the protective properties of greases. From the given data it is clear that the filler, as it were, acts as a surfactant and increases their effectiveness. Under ordinary conditions dense hydrocarbon greases are not susceptible to adjustment under the influence of a filler. In these greases fillers and SAS affect only the volume protective properties and find little reflection in the surface properties.

The introduction of inhibiters and fillers into soap greases is reflected first of all in their surface properties (the fraction of polarization resistance in the total resistance of the film is increased). In this case the protective effectiveness grows (see Table 2).

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